Disparities in Race/Ethnicity and Gender in In-Hospital Mortality Rates for Coronary Artery Bypass Surgery Patients

Edmund R. Becker, PhD and Ali Rahimi, MD, MPH
Atlanta, Georgia and New Haven, Connecticut

Background: While dramatic progress has been made lowering in-hospital mortality for coronary artery bypass graft surgery (CABG), few comprehensive studies have been done that include Caucasian, African-American, Hispanic and Asian-American/Pacific-Islander CABG inpatients and simultaneously evaluate the influence of gender. This study, analyzing five years of national data for 1.2 million CABG admissions, examines trends in in-hospital CABG mortality rates for gender and four racial/ethnic categories for CABG patients.

Methods: Using data from the Health Care Utilization Project (HCUP) for 1998–2002, 1.2 million CABG admissions were analyzed using descriptive and logistic regression analyses to evaluate the extent of the disparities in in-hospital CABG mortality rates. HCUP is a sample of nearly 1,000 hospitals from 35 states designed by the Agency for Healthcare Research and Quality (AHRQ) to approximate a 20% stratified sample of the nation's community hospitals: approximately 94% of all hospital discharges in the United States.

Results: Although significant progress has been made in recent years in lowering in-hospital CABG mortality, after controlling for relevant patient and socioeconomic factors, female CABG patients, regardless of their racial/ethnic group, still experience significantly higher in-hospital mortality rates than their male counterparts. Additionally, among these racial and ethnic groups, black CABG patients, whether male or female, continue to experience significantly worse in-hospital mortality rates than other races/ethnicities.

Conclusions: The declines in CABG in-hospital mortality rates have not been equal across race/ethnicity and gender.

Key words: CABG ■ gender ■ race/ethnicity ■ health disparities ■ health services research

 From Emory School of Public Health, Atlanta, GA (Becker) and Department of Internal Medicine, Yale School of Medicine, New Haven, CT (Rahimi). Send correspondence and reprint requests for *J Natl Med Assoc.* 2006;98:1729–1739 to: Dr. Edmund R. Becker, Emory School of Public Health, Department of Health Policy and Management, 1518 Clifton Road, NE, Atlanta, GA 30322; phone: (404) 727-9969; fax: (404) 727-9198; e-mail: ebeck01@sph.emory.edu

BACKGROUND

By almost any standards, the dramatic decline in coronary artery bypass graft surgery (CABG) in-hospital mortality rates for the treatment of coronary heart disease over the past decades has been extraordinary. National data from the Healthcare Cost and Utilization Project (HCUP) report that between 1993 and 2002, in-hospital CABG mortality declined from 3.33% to 2.30%—a 30.9% decline over the 10-year period. This decline in CABG in-hospital mortality was accomplished, while the lengths-of-stay for CABG admissions also declined 25.4% over this period and overall hospital admissions grew 2.03% (Table 1).[1]

Other data on CABG mortality rates within specific states show even more-pronounced trends mirroring the national decline.[2] CABG surgery mortality rate in New York State, for example, was reported at 2.24 per 100 patients in 1999, among the lowest ever reported in New York. The rate represented a substantial improvement over the 3.52 per 100 rate recorded in 1989, when the state of NY first began reporting CABG surgery outcomes.[3]

However, the aggregation of CABG in-hospital mortality rates over various hospital characteristics can mask substantial disparities that dramatically influence our perceptions of the decline. One area in CABG where these disparities are especially dramatic is in both race and gender. There is a considerable body of evidence that shows large and enduring disparities in the use of CABG procedures and outcomes by race[4-16] and by gender.[17-21] Studies have demonstrated that blacks and women have much lower rates of CABG surgery in the treatment of coronary heart disease,[23-25] and these lower rates are apparent even after statistical adjustments for the presence of specific clinical indications for CABG.[26-29] Moreover, these studies have shown that age-adjusted death rates for black patients have exceeded those of white patients[30] and that female gender is an independent predictor of in-hospital CABG mortality.[33]

However, many of these CABG research studies are based on randomized clinical trials or limited numbers of

hospitalized patients in a single setting, and these results may not be generalizable to the larger population of CABG patients undergoing treatment in U.S. hospitals. Moreover, as the Institute of Medicine noted, one of the most significant limitations of existing research on racial disparities is the failure to analyze differences in care beyond comparisons of black and white patients, and few studies have examined whether disparities in care exist for Hispanic and Asian-American populations.[34]

This study seeks to address some of these shortcomings using descriptive and logistic regression results (analyses) to examine recent national trends and the extent of current disparities in in-hospital CABG mortality rates by both patient race/ethnicity (whites, blacks, Hispanics and Asian Americans/Pacific Islanders) and gender over a five-year period for 1.2 million of the nation's CABG admissions. Our research seeks to answer two basic questions:

- Over the five-year period, 1998–2002, what is the extent of the differences in the rates of in-hospital mortality by race/ethnicity and gender for the nation's CABG patients?
- After controlling for patient characteristics, risk factors and socioeconomic characteristics of the hospital setting and environment, does in-hospital mortality differ across race/ethnicity and gender remain?

MATERIAL AND METHODS

The analyses used Nationwide Inpatient Sample (NIS) data from the Healthcare Utilization Project (HCUP) database for the calendar years 1998–2002. HCUP is a family of healthcare databases developed through a federal-state-industry partnership sponsored by the Agency for Healthcare Research and Quality (AHRQ).[35] HCUP contains all discharge data from a national sample of hospitals located in a cross-section of U.S. states. HCUP includes >100 clinical and nonclinical variables for each hospital stay and represents the largest publicly available all-payer inpatient care database in the United States with data for approximately 7.5 million hospital stays weighted to represent the nation's 37,187,641 discharges. In 2002, the HCUP contained a sample of nearly 1,000 hospitals from 35 states. The sample is designed annually by AHRQ to approximate a 20% stratified sample of the nation's community hospitals. For 2002, these hospitals comprised approximately 94% of all hospital discharges in the United States and a detailed discussion of the HCUP data collection and documentation at their website.[36]

CABG Patients

We focused our analysis on hospitalizations in which CABG was the primary diagnosis as defined by the International Classification of Diseases, 9th ed. Clinical Modification (ICD-9-CM codes 36.10-36.2). Our study pooled data from the 1998–2002 NIS releases for four races/ethnicities—white, black, Hispanic and Asian CABG patients. A total of 1,192,540 inpatients who underwent a CABG surgery procedure during the five-year period were analyzed (Table 2).

To ensure a consistent CABG population, a number of exclusions were made. First, all CABG patients with mitral or aortic valves done in conjunction with the CABG surgery were excluded (57,766 valve patients). Second, there were 38,281 CABG patients that did not have a known source of admission code and these patients were excluded. Third, all patients ≤18 years were excluded (121 patients). Finally, CABG patients whose source of admission was listed as court or law enforcement (205 patients), or whose type of admission was listed as newborn (118 patients) or other (634 patients) were excluded.

Over the five-year period, 594 hospitals performing CABG surgery were represented in the analysis. The mean number of CABGs for the 594 hospitals over the five-year period was 2,829 CABGs (SD=3,418) with a median of 1,665 patients per hospital.

Table 1. Ten-year trends in hospital CABG admissions, length of stay and in-hospital mortality rates

	Number of Cases	Mean LOS	Mortality Rate
1993	310,121	11.8	3.33%
1994	319,242	10.8	3.44%
1995	352,528	10.1	3.21%
1996	367,647	9.4	3.03%
1997	383,788	9.1	2.88%
1998	346,127	8.8	2.95%
1999	323,753	8.8	2.84%
2000	349,967	8.8	2.69%
2001	344,210	8.8	2.43%
2002	316,471	8.8	2.30%
10-year change	2.03%	-25.40%	-30.90%

Source: HCUPnet, Healthcare Cost and Utilization Project. Agency for Healthcare Research and Quality, Rockville, MD. www.ahrq.gov/data/hcup/hcupnet.htm

Data Aggregation

Patient characteristics, procedure complications, mortality and hospital process characteristics were coded from the HCUP hospital discharge records, which contain the principal diagnoses and procedures received by the patient. The definitions in the International Classification of Diseases—9th ed. (ICD-9) were used to aggregate patient characteristics and procedure complications into categories.[37]

Statistical Analysis

Since the HCUP database was drawn to be representative of all the CABG surgeries performed in the United States, patient characteristics and outcomes represented in the database are of interest. Descriptive CABG admission profiles are presented in Tables 2–4 for selected aspects of CABG for the five-year period, 1998–2002.

In addition, many aspects of a patient's health and clinical treatment have been shown to have an impact on their CABG inpatient outcomes, and these factors include a wide range of patient characteristics and comorbid conditions.[38,39] To test the independent influence of both gender and racial composition on mortality risk while adjusting for these other potential differences in the CABG population, we used logistic regression techniques and reported the odds ratios (ORs) and p values for the type of admission and source of admission categories in Table 5. To conserve space, Table 5 reports in-hospital CABG mortality descriptive statistics for race/ethnicity and gender variables only.

The logistic regression was performed with the dependent variable being in-hospital CABG mortality. There were 50 independent variables included in the logistic equation. These control variables include: 1) patient characteristics—age, gender, race (white—reference category, black, Asian and Hispanic), insurance coverage (Medicare, Medicaid, no charge, self-pay, other insurer and private insurer—reference category), median household income for the patient's ZIP code (<$25, $25–$35k, $35–$45k, >$45k—reference category); 2) patient risk factors and comorbid conditions (smoker, history of tobacco use, chronic obstructive pulmonary disease, insulin-dependent diabetes, noninsulin-dependent diabetes, conduction disorders, intracranial hemorrhage, acute renal failure, chronic renal failure, unspecified renal failure, liver disease, cerebral vascular disease, atrial fibrillation, ventricular fibrillation, hemodialysis, peritoneal dialysis, status-post CABG, status-post percutaneous transluminal coronary angioplasty, status-post permanent pacemaker, status-post implantable cardioverter-defibrillators, cardiogenic shock, hypertension, acute MI, old MI, cardiomyopathy, congestive heart failure, peripheral vascular disease, unstable angina, acute liver necrosis, endocarditis, mitral valve disease, aortic valve disease, mitral and aortic valve disease, chronic hepatitis); 3) other clinical characteristics (number of vessels bypassed, diagnostic cath, intra-aortic balloon pump (IABP), hypothermia use and heart pump); 4) medications (GPIIBIIIA and thrombolytics); and 5) time period (dummy variables representing each year with 2001 as the reference category). Many of these variables have been described elsewhere[40-43] and reflect conventional aspects of CABG surgery. Table 3 reports variable names, means, standard deviations and patient number of cases for CABG inpatients in the study. We tested the data for a random-effect versus a fixed-effect model using the Hausman test, and the results showed that a fixed-effect model was most appropriate.[44]

Table 4 reports regression results, ORs, p values, and lower and upper 95% confidence intervals for the independent variables. Hospital dummy variables for each hospital with one excluded were also included in the regression but not reported in Table 4.

DESCRIPTIVE RESULTS

CABG Counts and Percentages by Race/Ethnicity and Gender

Table 2 shows in-hospital CABG mortality rates, number of cases and percentage share of the total CABG population by race and gender for the 1998–2002 period. The vast majority of CABG procedures (87.3%) are performed on white admissions, while Asians/Pacific Islanders accounted for just 1.7% of the nation's CABG procedures. Combined, black and Hispanic CABG admissions accounted for the remain-

Table 2. In-hospital CABG mortality descriptive statistics by gender and race

	Females			Males			Total		
	Mean	N of Cases	Table	Mean	N of Cases	Table	Mean	N of Cases	Table
Whites	3.83	296,087	24.8%	2.23	744,554	62.4%	2.68	1,040,641	87.3%
Blacks	3.83	27,888	2.3%	2.91	36,103	3.0%	3.31	63,991	5.4%
Hispanics	3.24	21,212	1.8%	2.24	46,342	3.9%	2.56	67,554	5.7%
Asians	3.65	5,648	0.5%	2.56	14,705	1.2%	2.87	20,353	1.7%
Total	3.79	350,836	29.4%	2.26	841,704	70.6%	2.71	1,192,540	100.0%

Source: HCUP 1998–2002

ing 11% of inpatient admissions with nearly equal shares of CABG procedures for each group, 5.4% and 5.7%, respectively.

Men were considerably more likely to get a CABG procedure than women, 70.6% vs. 29.4%, respectively. Within each of the race/ethnic categories, the number of males receiving a CABG was more than twice the number of their corresponding female counterparts with the exception of black CABG admissions. For black CABG admissions, men still received the greatest share of CABG procedures, but the gender difference split was 56.4% for males vs. 43.6% for females. Taking into account both race/ethnicity and gender, nearly two-thirds of all CABG procedures (62.4%) were performed on white males, while white women had the second highest share of overall CABG procedures, with 24.8% over the five-year period.

Table 3. Variable names, means, standard deviations and patient counts

Variable Name	Mean	Standard Deviation	Number of Cases
Gender and Race/Ethnicity (%)			
White male	62.4	48.4	744,554
White female	24.8	43.2	296,087
Black male	3.0	17.1	36,103
Black female	2.3	15.1	27,888
Hispanic male	3.9	19.3	46,342
Hispanic female	1.8	13.2	21,212
Asian male	1.2	11.0	14,705
Asian female	0.47	6.9	5,648
Risk Factors (%)			
Smoker	12.0	32.5	143,440
History of tobacco abuse	10.7	31.0	128,061
Obesity	6.2	24.1	73,556
Insulin dependent diabetes	4.9	21.7	58,876
Noninsulin-dependent diabetes	26.0	43.9	309,961
Hypertension	62.0	48.5	739,249
Comorbidities (%)			
Chronic obstructive pulmonary disease	18.0	38.4	214,904
Congestive heart failure	16.7	37.3	199,137
Chronic renal failure	0.5	6.9	5,622
Unspecified renal failure	0.2	2.5	771
Hemodialysis	1.1	10.6	13,565
Chronic liver disease	0.34	5.8	4,021
Chronic hepatitis	0.16	4.0	1,885
Unstable angina	41.7	49.3	496,755
Peripheral vascular disease	8.7	28.1	103,120
Hyperchloremia (HCHL)	40.8	49.2	486,946
Cardiomyopathy	2.1	14.2	24,653
Acute MI	27.0	44.4	321,409
Old MI	34.8	14.1	167,637
Aortic valve disease	2.1	14.2	24,610
Mitral valve disease	1.0	10.1	67,078
Atrial and mitral valve disease	5.6	23.0	12,168
Atrial fibrillation	25.9	43.9	308,934
Ventral fibrillation	1.6	12.4	18,481
Conduction disorder	36.6	48.2	436,470
Status/post CABG	2.64	16.0	31,446
Status/postpercutaneous transluminal angioplasty	10.6	30.8	126,626
Status/postpermanent pacemaker	1.1	10.6	13,430
Status/postimplantable cardioverter defibrillators	0.16	4.0	1,922
Intracranial hemorrhage	0.03	1,83	401
Occlusion and stenosis of arteries with infarction	5.8	23.3	68,554
Transient cerebral ischemia	0.3	5.7	3,913
Aortic aneurysm and dissection	1.6	12.4	18,542
Endocarditis	0.02	1.52	274
Cerebral vascular disease (CVD)	8.7	28.1	103,344
Atrioventricular block	1.9	13,8	23,097
Cardiac dysrhythmias	30.7	46.1	365,998

In-Hospital CABG Mortality by Race and Gender

As shown in Table 2, in-hospital mortality rates varied quite dramatically by race/ethnicity and gender. While the overall in-hospital mortality rate averaged 2.71%, the female in-hospital mortality rate was 67.7% higher than male in-hospital mortality rate (3.79% vs. 2.26%; p<0.001), and the male's in-hospital mortality advantage over females was evident within each of the race/ethnic categories. White CABG admissions had the greatest gap between the male and female in-hospital mortality rates with a 71.7% differential, while the survival differences between gender was smallest (31.6%) for black CABG admissions.

Among males, blacks had the highest mean in-hospital mortality rate with 2.91% of them dying during their admission. Alternatively, white and black women each had an in-hospital mortality rate of 3.83%. It is interesting to

Table 3. continued

Variable Name	Mean	Standard Deviation	Number of Cases
Procedure Characteristics (%)			
Number of vessels bypassed	3.31	1.10	1,192,540
Arteries utilized	81.4	39.0	970,072
Veins utilized	94.7	22.3	1,128,871
Diagnostic cath	60.0	49.0	714,121
IABP	7.8	26.8	92,613
Intermittent hemodialysis	0.3	5.6	3,776
Cardiogenic shock	1.6	12.6	19,100
Medications (%)			
Thrombolytics	0.3	5.8	3,972
GPIIbIIIa	1.8	13.2	21,308
Payer Coverage (%)			
Private and HMO insurance	37.7	48.5	449,775
Medicare	53.5	49.9	638,062
Medicaid	3.9	19.3	46,327
Self pay	2.1	14.4	25,084
No insurance	0.22	4.7	2,662
Other insurance	2.4	15.2	28,051
Median Household Income in ZIP Code (%)			
<$25,000	5.1	21.6	58,408
$25,000–$35,000	27.4	44.1	315,854
$35,000–$45,000	29.4	45.1	338,490
>$45,000	38.1	37.5	437,938
Admission Type (%)			
Elective	43.9	41.6	463,403
Urgent	27.6	43.0	291,565
Emergency	28.4	43.4	300,104
Admission Source (%)			
Routine	56.5	44.2	652,764
Another hospital	17.3	37.4	199,930
Another facility	3.4	18.0	39,759
Emergency room	22.8	41.5	263,385
Patient Age (%)			
<40	0.9	9.5	10,877
40–49	7.1	25.6	84,062
50–59	21.2	40.8	252,328
60–69	30.5	46.1	363,976
70–80	31.9	46.6	380,909
>80	8.4	27.8	100,346
Year of Procedure (%)			
1998	21.7	39.2	258,614
1999	19.4	38.5	230,765
2000	21.2	40.9	253,319
2001	21.0	40.7	250,316
2002	16.7	37.3	199,524

* 594 hospital dummy variables for each hospital were also included in the logistic regression with one excluded as the reference category but not reported here to save space.

note that the in-hospital mortality rate gap is generally greater between genders than among the racial/ethnic categories. That is, the range in in-hospital mortality across the four racial/ethnic groups is 0.59% (3.24–3.82%) for females and 0.68% (2.23–2.91%) for males. However, for each of the racial/ethnic groups, the differences between male and female CABG patients range is 0.92% (2.91–3.83%) for blacks to 1.6% for whites (2.23–3.83%).

Characteristics of the Nation's CABG Population

As shown in Table 3, >70% of the nation's CABG admissions for the five-year period were >60 years of age, with 62% exhibiting hypertension, 41.7% reporting unstable angina, 30.7% had cardiac dysrhythmias and 60% receiving a diagnostic catheterization during the admission. Of the nation's CABG admissions over the

Table 4. In-hospital CABG mortality logistic regression results, p values and 95% confidence intervals

			95% CI	
	Odds Ratio	p Value	Lower	Upper
Gender and Race/Ethnicity				
White male	RC	RC	RC	RC
White female	1.443	<0.001	1.403	1.484
Black male	1.356	<0.001	1.260	1.459
Black female	1.556	<0.001	1.444	1.676
Hispanic male	0.988	0.763	0.914	1.068
Hispanic female	1.192	<0.001	1.083	1.312
Asian male	1.064	0.338	0.937	1.207
Asian female	1.420	<0.001	1.200	1.681
Risk Factors				
Smoker	0.558	<0.001	0.527	0.591
History of tobacco abuse	0.483	<0.001	0.454	0.515
Obesity	0.729	<0.001	0.674	0.788
Insulin dependent diabetes	1.188	<0.001	1.126	1.253
Non-insulin dependent diabetes	0.815	<0.001	0.789	0.842
Hypertension	0.672	<0.001	0.654	0.690
Comorbidities				
Chronic obstructive pulmonary disease	1.180	<0.001	1.144	1.217
Congestive heart failure	1.457	<0.001	1.417	1.499
Chronic renal failure	1.534	<0.001	1.382	1.704
Unspecified renal failure	4.291	<0.001	3.467	5.311
Hemodialysis	6.224	<0.001	5.853	6.618
Chronic liver disease	9.850	<0.001	8.740	11.101
Chronic hepatitis	0.476	<0.001	0.386	0.587
Unstable angina	1.055	0.001	1.022	1.088
Peripheral vascular disease	1.309	<0.001	1.259	1.362
Hyperchloremia	0.537	<0.001	0.519	0.555
Cardiomyopathy	1.208	<0.001	1.133	1.288
Acute MI	1.333	<0.001	1.290	1.378
Old MI	0.727	<0.001	0.693	0.761
Aortic valve disease	1.484	<0.001	1.391	1.583
Mitral valve disease	1.039	<0.001	0.995	1.085
Mitral and aortic valve disease	1.220	<0.001	1.115	1.335
Atrial fibrillation	0.276	<0.001	0.266	0.287
Ventral fibrillation	2.016	<0.001	1.913	2.125
Conduction disorder	0.829	<0.001	0.776	0.886
Status-post-CABG	1.562	<0.001	1.460	1.672
Status-postpercutaneous transluminal angioplasty	0.714	<0.001	0.673	0.757
Status-postpermanent pacemaker	0.859	0.009	0.766	0.962
Status-postimplantable cardioverter defibrillators	0.833	<0.001	0.723	0.934
Intracranial hemorrhage	11.164	<0.001	8.711	14.308
Occlusion and stenosis of arteries with infarction	2.662	<0.001	2.565	2.762
Transient cerebral ischemia	0.503	<0.001	0.385	0.657
Aortic aneurysm and dissection	2.350	<0.001	2.193	2.518
Endocarditis	2.804	<0.001	1.876	4.192
Cerebral vascular disease (CVD)	1.433	<0.001	1.145	2.331
Atrioventricular block	0.884	0.002	0.819	0.954

five-year period, 26% had noninsulin-dependent diabetes, while 4.9% had insulin-dependent diabetes. On average, 3.3 vessels were bypassed with both arteries and veins being utilized. The majority of CABG admissions (53.5%) had Medicare as their primary payer, while 37.7% had private or HMO insurance coverage. Only 5.1% of CABG inpatients came from ZIP code areas where the median income was <$25,000. The largest shares of CABG admissions were reported as elective (43.9%) and routine (56.5%).

Table 4. continued

			95% CI	
	Odds Ratio	**p Value**	**Lower**	**Upper**
Dysrhythmias	5.485	<0.001	5.108	5.891
Procedure Characteristics				
Number of vessels bypassed	1.001	0.853	0.987	1.016
Veins utilized	0.741	<0.001	0.694	0.792
Arteries utilized	0.638	<0.001	0.619	0.658
Diagnostic cath	0.937	<0.001	0.910	0.965
IABP	3.920	<0.001	3.801	4.044
Intermittent hemodialysis	0.984	0.827	0.856	1.132
Heart pump	0.999	0.960	0.967	1.033
Cardiogenic shock	5.129	<0.001	4.915	5.353
Medications				
GPIIBIIIA	0.762	<0.001	0.697	0.833
Thrombolytics administered	0.539	<0.001	0.435	0.669
Payer Coverage				
Private pay or HMO	RC	RC	RC	RC
Medicare	1.368	<0.001	1.316	1.422
Medicaid	1.364	<0.001	1.265	1.469
Self-pay	1.371	<0.001	1.239	1.516
No charge	0.957	0.801	0.681	1.345
Other insurance	0.897	0.047	0.805	0.999
Median Household Income in ZIP Code				
ZIP income <$25,000	0.892	<0.001	0.836	0.950
ZIP income $25,000–$35,000	1.014	0.455	0.977	1.052
ZIP income $35,000–$45,000	1.021	0.220	0.988	1.055
ZIP income >$45,000	RC	RC	RC	RC
Admission Type				
Elective	RC	RC	RC	RC
Emergency	1.079	0.002	1.029	1.131
Urgent	1.030	0.137	0.991	1.072
Admission Source				
Routine	RC	RC	RC	RC
Emergency room	1.018	0.439	0.974	1.063
Another hospital	1.071	0.001	1.029	1.115
Another long-term facility	0.978	0.560	0.906	1.055
Patient Age				
<30	RC	RC	RC	RC
40–50	0.920	0.427	0.750	1.130
50–60	1.459	<0.001	1.203	1.769
60–70	1.943	<0.001	1.604	2.354
70–80	3.059	<0.001	2.523	3.710
>80	4.502	<0.001	3.706	5.469
Year of Procedure				
1998	RC	RC	RC	RC
1999	1.027	0.289	0.978	1.078
2000	0.979	0.382	0.932	1.027
2001	0.930	0.006	0.884	0.979
2002	0.949	0.066	0.897	1.004
Constant	0.012	<0.001		

* 594 hospital dummy variables included in the logistic regression (with one excluded) but results not reported; RC: reference category

MULTIVARIATE ANALYSES—LOGISTIC REGRESSION RESULTS

Other Covariate Results

To examine how patient characteristics and comorbid conditions correlate with race/ethnicity and gender as well as how these variables impact in-hospital CABG mortality rates, we used multivariate regression techniques. Using in-hospital mortality as the dependent variable, we controlled for >50 independent variables (as described in Table 3), which include patient characteristics, patient risk factors and comorbid conditions, CABG procedure characteristics, medications and timeframe.

Logistic regression analysis was used with the dependent variable—in-hospital mortality, a binary variable, and the ORs and p values of all the major variables were reported in Table 4. To save space, we omitted the 594 dummy variables that were included to represent each of the study hospitals with one excluded as the reference category.

The four race/ethnicity categories (whites, blacks, Hispanics and Asians/Pacific Islanders) were divided into male and female groupings to define eight race/ethnicity and gender groupings. White male CABG admissions were the excluded reference category in the logistic regression. Table 5 reports the percentage differences in in-hospital mortality rates from the logistic regression results for just the race/ethnicity and gender results derived from Table 4.

Logistic regression results shown in Table 4 reveal the significant impacts of many comorbid and socioeconomic characteristics. For example, many comorbid conditions such as unspecified renal failure, hemodialysis, chronic liver disease, cardiogenic shock, aortic aneurysm and dissection, intracranial hemorrhage, occlusion and stenosis of arteries with infection, dysrhythmias, ventral fibrillation and IABP all significantly increase the likelihood of in-hospital CABG mortality by >100%.

Similarly, when compared to private paying or HMO CABG patients, Medicare, Medicaid and self-paying patients all had significantly higher in-hospital mortality rates that ranged between 36–37%. As revealed in Table 4 and as might be expected, as CABG patients get older, their likelihood of dying increases within each age category. Compared to the reference category, CABG patients aged <30 years and CABG admissions that were 70–80 years old were >3 times more likely (OR=3.059; p<0.001) to experience in-hospital mortality, while CABG admissions ≥80 years old were four times more likely (OR=4.502; p<0.001) to suffer in-hospital mortality. Overall, the nation's in-hospital CABG mortality generally declined each year since 1998 up through 2001, although only in the years 2001 and 2002 were the results significant.

Table 5. In-hospital CABG mortality percentage differences for logistic regression results by gender and race after controlling for other covariates

	Female	Male
White	44.3%***	RC
Black	55.6%***	35.6%***
Hispanic	19.2%***	-1.21%^{NS}
Asian	42.0%***	6.4%^{NS}

NS: not statistically significant; * p<0.5; ** p<0.01; *** p<0.001; RC: reference category

Race/Ethnicity and Gender Logistic Regression Results

Table 5 reports percentages of the difference among the logistic regression results from Table 4 for race/ethnicity and gender when compared to the excluded reference category—white male CABG patients. Focusing on male CABG patients, when compared with white male CABG patients, Hispanic and Asians males show no significant differences in their in-hospital mortality rates. However, black male CABG patients were 35.6% more likely to die than white male CABG patients (p<0.001).

Examining female CABG patients, it appears that all four racial/ethnic categories experienced significantly higher (p<0.001) in-hospital mortality rates when compared with the reference category, white male CABG patients. Hispanic women revealed the lowest in-hospital rate differential from white males with a 19.2% increase, while black women experienced a 55.6% increase in in-hospital mortality. White and Asian women had similar rates relative to white male patients—44.3% and 42.0%, respectively.

DISCUSSION

Examination of in-hospital CABG mortality trends using both the race/ethnicity and gender over a five-year period reveals the dynamic nature of in-hospital CABG mortality rates. HCUP trend data confirm the extraordinary progress surgeons and hospitals have made in improving CABG mortality rates over the past decade. The nation's in-hospital mortality rates have continued to decline as CABG patients' lengths of stay have also fallen. However, the decline in in-hospital mortality rates have not been equal across races/ethnicities and gender.

Over the five-year study period, both univariate and logistic regression data show the disadvantage females have, regardless of their race/ethnicity, when compared to their male counterparts in in-hospital CABG mortality rates. Female CABG inpatients have significantly higher in-hospital mortality rates than their corresponding male counterparts regardless of their race even after controlling for patient characteristics and socioeconomic conditions. Compared to their male racial/ethnic counterpart, females were 19% (Hispanic females) to 56% (black

females) more likely to die. These findings are consistent with recent studies that have suggested that, on average, women have a disadvantageous preoperative CABG clinical profile. This includes the fact that women present for treatment at an older age; with poorer LV function; more frequently with unstable angina pectoris, NYHA class-4 heart failure, three-vessel and left main disease; and with more comorbid conditions, including hypothyroidism, renal disease, diabetes mellitus, hypertension and peripheral vascular disease[45-49] These factors may contribute to poorer CABG outcomes.

For males, however, the likelihood of dying in the hospitals from a CABG procedure showed a wide split across the four racial/ethnic categories. For three of the racial/ethnic groupings, there were no significant disparities. Compared with white male patients undergoing CABG surgery in the nation's hospitals, all things being equal, Hispanics and Asian Americans/Pacific Islanders did not differ significant in their in-hospital mortality rates from white male patients. In contrast, black male CABG patients had a 35.6% higher in-hospital mortality rate than white males. Thus, only black males appeared to not benefit from the gender advantage traditionally found in CABG research.

Moreover, among the racial and ethnic groups, black CABG patients, whether male or female, had significantly worse in-hospital mortality rates among the four racial/ethnic groups analyzed even after accounting for numerous characteristics that impact hospital care, including patient characteristics, insurance status, comorbid illness, procedure severity and characteristics of the hospital's setting.

There are a number of possible explanations for these persistent racial/ethnicity and gender differences, and these warrant further investigation. First, it is well documented that access and treatment problems persist by race.[50] To what extent do these differences in diagnosis and treatment patterns prior to hospitalization result in black CABG patients arriving at the hospital in poorer health? While our study controlled for many more patient, organizational and socioeconomic aspects of CABG patients' condition and treatment than virtually any other study to date, there still may be other unmeasured social phenomena of the patient's background, health condition or hospital stay that may help explain racial/ethnic and gender differences. For example, patients' ability to afford care,[51] their knowledge and beliefs,[52] their preferences[53] and their level of activation[54] may all play an important role.

Second, what is the extent of the differences in CABG outcomes across hospitals and physicians? For instance, do hospitals or physicians that have more experience with CABG patients or higher volumes of CABG patients show the same persistent differences in CABG in-hospital mortality rates across race/ethnicity? There is evidence to suggest that black patients were more likely to undergo CABG at hospital with the highest mortality and at hospitals in the lowest CABG volume cohorts[55] and that structural features of the delivery system (race of treating physician, board certification, degree of physician subspecialization, availability of high-quality diagnostic imaging and ancillary services, and type of hospital admission) might also contribute to racial disparities in the care inpatients receive.[56] In addition, many aspects of the physician–patient relationship that involve patients' education,[57] trust[58] and the physician's sensitivity to a patient's culture[59] might also play a critical role.

Finally, others have identified genetic differences in race/ethnicity that could account for differences in outcomes. In breast cancer research, for example, biological evidence shows that black women with breast cancer are four times more likely than white women with breast cancer to have mutations in a gene called p53. The p53 gene is known to help suppress tumors and be associated with a poor prognosis for breast cancer after adjusting for other factors.[60] Other evidence in Alzheimer's disease shows that blacks and a group of Hispanic Americans mainly from the Caribbean with a certain gene (apolipoprotein E-4) have been found to be at much greater risk than whites for Alzheimer's.[61] For patients with heart disease, some have also suggested there are subtle differences among race/ethnicities in the biology of hypertension.[62] Potential differences in the biology of hypertension may result in more frequent and more severe hypertension, ventricular hypertrophy, and enlargement of the heart's chambers in black patients. Consistent with this research, in our data, >75% of black CABG patients had hypertension, which is 13% higher than the CABG population average of 62%. Further research is needed to explore these potential biological markers and determinants.

LIMITATIONS

We recognize there are a number of important limitations with our data, and our results should be interpreted cautiously. While HCUP provides an opportunity to describe inpatient practice patterns for large racial/ethnic populations on a national level, HCUP data represent only CABG admissions and, given the substantial differences in access that exist across the different racial/ethnic groups, they may not fully represent the extent of disparities among racial/ethnic groups. While our research population and regression covariates exceed regression requirements and parameters, other factors such as the clinical severity of illness or secondary illnesses that are not taken into account in the database could be relevant and impact our results. In particular, clinical data related to the size and location of the CABG and symptom severity scores would be helpful to better understand the decision-making process for physicians and patients. In addition, it would be helpful

to have data on longer-term CABG survival rates for these patients. Finally, the physician's intension to treat cannot be determined.

Nevertheless, in spite of these limitations, our investigation currently represents one of the largest and most comprehensive studies of CABG in-hospital mortality focusing on race/ethnicity and gender. We expected the multivariate results to show, after the inclusion of the extensive number of covariates, that most of the discrepancies between gender and the racial and ethnic classifications would disappear. Clearly, they do not. Thus, although progress is being made in lowering the nation's in-hospital mortality rates among the major racial/ethnic groups, black CABG patients, whether male or female, appear to be among the last experiencing these benefits.

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